The Municipal Gazette

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RATEPAYERS' MEETING

RESOLUTION VIII (ADDITIONAL ELECTRICAL PLANT)

With reference to the minute contained in the Municipal Gazette of December 8, the following documents are published for general information :---

(i) Report by Messrs. Preece, Cardew & Snell
(ii) Confirmatory letter from Mr. Mayne
(iii) Report by the Electrical Engineer of March 14, 1911.

W. E. LEVESON,
Secretary.

Council Room,
Shanghai, March 20, 1911.

(I.)

8 Queen Anne's Gate,
Westminster, S.W.,

January 31, 1911.

We have the honour to report that in accordance with your instructions, we have prepared in conjunction with the Electrical Engineer, the complete scheme for the new Riverside Generating Station on the Yangtzepoo Road. The scheme as submitted to you by the Electrical Engineer was largely based upon the proposals which were discussed with Mr. A. H. Preece in 1907. The final arrangements embody the most recent developments in electric power plants, and we consider that the Council will be placed in a position to supply electricity for lighting and for power at a very low rate, and to cope with the increasing demands of the Settlement.

The estimated cost of the scheme submitted by Mr. Aldridge amounted to £73,540 exclusive of the foundations and other local work. This appears to be somewhat in excess of the actual requirements. The tenders for those portions of the work which have already been received are well below the estimates, and we have every reason to think that the total cost will not exceed £65,000.

The buildings will be of steel skeleton construction and the walls will be partly of brick and partly of galvanized iron. The boiler house will contain 4 watertube boilers, of which 3 will be capable of supplying the necessary steam for 4,000 K.W.

In the engine-room there will be two 2,000 K.W. turbo-generators, complete with condensing plants, one for each turbine, placed in the basement. Switchgear of latest pattern will be provided on the galleries, and everything will be arranged so that the station can be run as a bulk supply station in conjunction with the Fearon Road plant. Water for condensing purposes will be delivered from the river by means of pumps placed in a separate pumphouse.

With regard to the coaling arrangements, a small dock is proposed to be provided on the riverside to which barges would have access. From these barges the coal will be delivered by means of cranes into conveyors, and automatically delivered into the various coal bunkers.

The current generated at the station will be taken by means of underground mains, of which there will be three, to Fearon Road. So far as can be reasonably carried out, everything is provided in sections, so that the failure of any one portion of the work will not interfere with the continuity of supply.

The specifications have been prepared and issued jointly by Mr. Aldridge and ourselves. The time available has been somewhat limited, and it has been necessary to issue the different sections of the work gradually.

The following is a list of the sections into which the work is being divided :—

Section 1. Turbo Generators
,, 2. Boilers
,, 3. Steelwork for Buildings
,, 4. Main Switchboards
,, 5. Transformers
,, 6. Coal handling gear
,, 7. Steam and other pipes
,, 8. Pumping Plant
,, 9. Cables.

It has not been possible to obtain tenders for all the sections. We have however, dealt with the principal items of expenditure, viz., Section 1, the Turbo-Generators, Section 2, the Boilers, Section 4, the Switchboard, Section 5, the Transformers, Section 9, the High Tension Mains. The other sections will be reported upon in a supplemental report.

TURBO-GENERATORS—No. 1 Section.

The specification issued provided for two sets of plant of about 2,000 K.W. with condensing plant. We did not specify the exact size, as it was possible that some firms might have a standard size a little larger or smaller. We also did not definitely specify the speed at which the turbines were to run, but we stated that speeds of 1,500 and 3,000 revolutions would receive consideration. The two standard speeds to give the correct periodicity for this size of plant are 1,500 and 3,000.

The result of the tendering has been that there is considerable divergence in the offers received. Many firms quote alternatively, but in the following list we give the best offers received from the various firms for different sizes of plant:—

Name of Firm.	Maker of Generator	Price £	Size of plant K.W.	Speed r.p.m.	Steam at full load lbs.	Time for delivery weeks.
Richardson Westgarth & Co.	Siemens	12,025	2,000	3,000	14.66	40—44
Willans and Robinson	do.	12,050	do.	do.	15.15	34
Allgemeine Elektricitats Gesellschaft	A. E. G.	12,455	do.	do.	14.45	21- 26
Fraser & Chalmers	Siemens	12,500	do.	do.	16.00	36—46
British Westinghouse Co.	Westinghouse	12,547	do.	do.	14.9	28
Howden & Co.	Siemens	13,053	do.	do.	15.0	26—31
Escher Wyss & Co.	do.	13,164	do.	do.	14.4	25—29
British Thomson Houston Co.	B. T. H.	13,192	do.	do.	14.8	Subject to tests
Oerlikon Co.	Oerlikon	13,290	2,500	do.	14.7	30—35
Brown Boveri & Co.	Boveri	13,307	2,000	do.	15.4	40
A. E. G.	A. E. G.	14,225	2,000	1,500	15.4	22—26
Willans & Robinson	Siemens	14,360	2,000	do.	15.2	34
C. A. Parsons & Co.	Vickers	14,560	do.	do.	15.4	32
B. T. Houston Co.	B. T. H.	14,580	do.	do.	16.25	22—26
A. E. G.	A. E. G.	15,025	do	do.	14.75	22—26
British Westinghouse Co.	Westinghouse	15,432	2,500	do.	15.9	28
Dick-Kerr & Co.	Dick Kerr	15,454	do.	do.	15.1	36
Parsons & Co.	Parsons	15,861	2,000	do.	15.4	32
Brush Co.	Brush	16,036	2,500	1,500	15.5	32
Escher Wyss & Co.	Siemens-Schuckert	16,282	2,000	do.	15.6	43
Howden & Co.	Siemens	16,933	do.	do.	15.0	26—31
Belliss & Morcom	do.	17,218	2,500	do.	14.72	40—42
Maschinen Augsburg	do.	17,638	do.	do.	14.8	40—42
Batt & Company	do.	18,675	do.	do.	15.4	44—42

There are numerous alternative offers, but the above are the best submitted.

Some tenders have also been sent in for 2,500 K.W. plants at 3,000 revolutions. Messrs. Willians tender was originally for 2,500 K.W., but they subsequently sent in the alternative given above.

Messrs. Bruce Peebles and the General Electric Co. quoted for the generator portion only.

The price quoted by the British Westinghouse Co. was increased by £248 to provide a larger condenser. The Allgemeine Elektricitats Gesellschaft on the other hand reduced their prices by £1,120, as they had included turbine-driven circulating water pumps, which were not specified. Various other tenders were slightly altered from the first prices received due to modifications required to bring tenders upon the same basis.

The foregoing schedule may be divided into two sections, (a) Tenders for turbines running at 1,500 revolutions per minute, and (b) Tenders for turbines at 3,000 revolutions. The higher speed means a lower price, and a slightly better steam consumption. The saving in capital is about £3,000.

We are ourselves in favour of the lower speed of 1,500 revolutions, especially for plant which has to be operated in isolated places such as Shanghai, but in view of the extra capital involved, we have decided to refer the matter for final decision to the Council.

A difference of £3,000 on the capital may be of considerable importance, and as firms of repute are prepared to guarantee plant at 3,000 revolutions per minute, the Council may think it desirable in the interests of the undertaking to entrust the contract to one of these firms, although we think some risk is involved. The advance in the details of construction of plants of this character is very rapid, and what one looks upon as risky this year may possibly become common practice in a few years.

Our chief objections to the high speed with turbines and generators of 2,000 K.W. capacity or over are the mechanical difficulties in construction and the prevention of overheating through want of ventilation. The peripheral speed of the rotor reaches some 20,000 feet per minute or 230 miles per hour, and it is obvious that a built-up rotor requires extremely careful workmanship and selection of material to ensure safety for continuous working at such speeds.

As regards heating, the higher speed reduces the size of the rotor, but as the amount of heat generated remains almost the same, it is necessary to provide for a greatly increased supply of air to carry off the heat. This is done by induced or forced draught. In Shanghai, the air in summer is over 90 degrees Fahr., and it is doubtful whether overheating can be avoided unless special water cooling arrangements are adopted.

Our opinion is largely confirmed by some firms who are not driven by modern competition to incur any risks to secure an order.

The British Thomson Houston Company, who carry out excellent work in England, and who are the British branch of the General Electric Company of America, state definitely in their tender that though their practice in England is to use 3,000 revs. for plant up to 2,000 K.W. they do not think such speeds are desirable for plant in Shanghai. They have, however, submitted an alternative tender at this speed, but if accepted they would require to run the plant for 3 months before shipment to ensure its absolute safety.

Assuming the Council accept our recommendation to adhere to 1,500 revolutions, the lowest tender is that of the Allgemeine Elektricitats Gesellschaft at £14,225. They are followed by Messrs Willans & Robinson with Siemens' generators at £14,360. Messrs Parsons & Co. with Vickers. £14,560, the British Thomson Houston Co. £14,580, the Allgemeine Elektricitats Gesellschaft alternative £15,025, the British Westinghouse Company (for 2,500 K.W.) £15,432. and so on. There is very little difference beween these tenders as regards construction of the turbine. They all have their particular advantages. The Allgemeine Elektricitats Gesellschaft, the Westinghouse Company, and the British Thomson Houston Company are essentially of the impulse type, whereas Messrs. Willans, Parsons and Richardson Westgarth are combined impulse and reaction. With regard to the generators, the construction is different in most cases, but each firm is confident that its own is the best that can be made.

The main difference, however, in these tenders is in the steam consumption. It will be noticed that the Allgemeine Elektricitats Gesellschaft's higher tender gives the best steam consumption. This is due to the fact that they have more stages in the turbine. The British Thomson Houston and other firms could improve their steam consumption if a similar alteration were made, but this again would bring their price up much above the Allgemeine Elektricitats Gesellschaft.

We recommend the tender of the Allgemeine Elektriciats Gesellschait and prefer the higher tender at £15,025 in order to obtain the better steam consumption. We should much like to have recommended the tender of the British Thomson Houston Company. Their turbine is excellent, and their generator is good. We have called their attention to the high steam consumption, but they preferred to adhere to what they guaranteed. They told us that they hoped they would get a better result, but they did not think they were justified in guaranteeing one. They also considered that the plant they had quoted was best suited for Shanghai, and might be expected to maintain the guarantee for many years.

Should the Council decide to adopt the higher speed of 3,000 revolutions, we see no reason to reject the lowest tender—that of Messrs. Richardson Westgarth with Siemens' generator. Messrs. Richardson Westgarth build turbines of the design by the well-known Swiss firm Brown Boveri & Co., and have done very good work in this country. Messrs. Siemens generators are excellent, and we are satisfied that of the design submitted for high-speed generator, the one proposed by them is probably the safest—its construction is very solid. The steam consumption of Messrs. Richardson Westgarth's tender is very good.

The Allgemeine Elektricitats Gesellschaft's steam consumption is slightly better than Richardson Westgarth, but the difference is so small that we do not think it can justify the additional expense of £430. The steam consumption of Messrs. Willans and Robinson's tender is not so good as Messrs. Richardson Westgarth, and the type of turbine they propose has no special advantages

The result of the above recommendation is that if the Council decides to adopt a speed of 3,000 revolutions, they should accept the tender of Messrs. Richardson Westgarth with Siemens' generators, at £12,025, but on the other hand, if they adopt our suggestion regarding the speed they should accept the tender of the Allgemeine Elektricitats Gesellschaft at £15,025.

The sum provided by Mr. Aldridge was £30,000 including some pipework and sundries which would amount to about £4,000. There is thus a considerable saving over the estimate.

BOILER HOUSE—No. 2 Section.

In reply to our advertisement, tenders were received from the following firms:—

Messrs. Howden & Co., Ltd.	13,027
,, Clarke Chapman & Co. (with alternatives)	14,264
,, Babcock & Wilcox, Ltd.	14,495
,, Hawksley Wild & Co.	15,028
,, Fraser & Chalmers	20,295

Of the above tenders. Messrs. Howden propose a boiler which has not yet been thoroughly tested in the market. It is only in an experimental stage, and under these circumstances we did not think it advisable to consider their tender further. The next tender, that of Messrs. Clarke Chapman & Co. proposes "Woodeson" boilers, which is a satisfactory type, but in view of the fact that Messrs. Babcock & Wilcox' boilers are already installed in Shanghai, giving most satisfactory results, we prefer to adhere to their make, especially in view of the fact that the difference in price is so small.

Messrs. Babcock & Wilcox had quoted in their tender for some additional work in connexion with the chimneys, which is not required, and they are prepared to carry out the work specified for the sum of £14,305. Under these circumstances, we decided that their tender was the best to be accepted, and we are provisionally accepting their tender.

The tenders of Messrs. Hawksley Wild and Messrs. Fraser & Chalmers do not offer any advantages over the other tenderers.

The plant included in Messrs. Babcock & Wilcox' tender of £14,305 consists of the four boilers, stokers, economisers, steel shafts, flues and dampers, etc., but does not include the pipework. The sum provided by Mr. Aldridge for this section of the work was £18,000. Assuming the cost of the pipework does not exceed £2,000, which appears to us ample for the work, the total cost of this section will not exceed £16,500, or a saving of £1,500.

STEELWORK FOR BUILDINGS.—No. 3 Section.

Tenders for this section have not yet been received. They are due on February 2.

MAIN SWITCHGEAR—No. 4 Section.

The following tenders have been received:—

	£	s.	d.
The Union Electric Co.	1,415	0	0
Cowans Ld.	1,428	0	0
General Electric Co. (England)	1,445	0	0
British Westinghouse Co.	1,512	5	0
Cox-Walkers Ld.	1,515	0	0
Spagnoletti Ld.	1,571	0	0
Allgemeine Elektricitats Gesellschaft	1,592	0	0
Siemens Bros. & Co. Ld.	1,613	0	0
Johnson & Phillips	1,643	0	0
Bertram Thomas	1,753	0	0
Electric Construction Co.	1,798	10	0
Ferranti Ld.	1,817	5	6
Reyrolle Ld.	1,895	0	0
Brown Boveri Ld.	1,985	0	0
British Thomson Houston Co.	2,744	10	0
Crompton & Co. Ld.	3,138	0	0

The designs of boards and types of switches vary very much in character. We have carefully considered the different offers, and have concluded that the tender of the British Westinghouse Company Ld. is the most satisfactory in design at the price offered, and we propose to provisionally accept their tender.

TRANSFORMERS—No. 5 Section.

The following tenders have been received for the transformers required for the generating station, and for one of the first substations:—

	£
Allgemeine Elektricitats Gesellschaft	620
The Brush Electrical Eng. Co. Ld.	626
Johnson & Phillips	666
British Electric Transformer Co.	674
British Westinghouse Co.	680
Oerlikon Company	680
Allgemeine Co. (alternative)	700
Siemens Bros. & Co , Ld.	804

The lowest tender, namely, that of the Allgemeine Elektricitates Gesellschaft, is satisfactory, and we have provisionally accepted their tender at £620.

CABLES—No. 9 Section.

The following tenders have been received:—

	£	s.	d.
R. R. Todd (The Lahmeyer Co.)	12,078	15	0
Messrs. Siemens Bros., London	12,079	5	0
The Allgemeine Elektricitats Gesellschaft	12,222	0	0
The Western Electtic Co. Ld.	12,226	12	6
The British Insulated & Helsby Cables Ld.	12,338	1	0
W. T. Henley's Telegraph Works	12,380	13	0
Callenders Cable Co. Ld.	13,182	3	0
W. T. Glover & Co. Ld.	13,325	1	0
The Union Company	14,030	13	0
The General Electric Co. Ld.	14,046	2	7

We carefully considered the above tenders, and in view of the fact that Messrs. Siemens' cable will be made at Woolwich, while Mr. Todd's are made at Cologne, the extra cost of 10s. was fully justified, owing to the reduced expenses of inspection and testing in England as compared with Germany.

We decided to provisionally accept Messrs. Siemens' tender.

PREECE, CARDEW & SNELL.

(II.)

London, February 4, 1911.

SIR,—Referring to the instructions contained in your letter of December 10 last I have to report that I have co-operated with the Electrical Engineer and Messrs. Preece, Cardew & Snell, the Council's Consulting Electrical Engineers in the selection of the tenders referred to in the Consulting Engineer's report to the Council dated the 31st ultimo and which is now being forwarded.

I have had a considerable number of interviews with Messrs. Preece, Cardew & Snell who have afforded me the fullest possible information in regard to the various points at issue and I am now able to approve the recommendations in reference to the various tenders contained in the report.

The questions involved in regard to the settlement of the tender for the turbo-generators are somewhat technical.

The Consulting Engineers have stated their views on the matter very lucidly to me and there is not any doubt in my mind as to the desirability of adopting their special recommendation.

Clauses have been inserted in all the specifications as to tenders holding good until after the Ratepayers' Meeting and provision has also been made in regard to fluctuations that may occur in the price of copper.

I am, Sir,
Your obedient servant,
CHARLES MAYNE.

W. E. LEVESON, Esq.,
Secretary,
Municipal Council.

(III.)

Shanghai March 14, 1911.

I have the honour to present my Report on the special work upon which I have been engaged in Europe, and also to offer some general remarks upon the past year's working of the Electricity Department together with a forecast of the future development of the undertaking. I regret that I was unable to complete my work in England sooner as the delay in my return has prevented the presentation of this report at an earlier date.

. The primary object of my visit to Europe being in connexion with the Department's development scheme in general and with the design and equipment of the new Riverside power station in particular, it may be well to explain that the scheme now awaiting the ratepayers' approval is in practically every detail the same as outlined in my report No. 37/10 dated Oct. 7, 1910.

Land.—It is intended to erect the proposed Power House on the site specially purchased for this purpose during 1908.

Buildings.—The views I hold regarding electric power stations are perhaps the natural outcome of competition. I regard a power station purely as a factory for supplying at the lowest possible cost—electricity. The generation and supply of electric energy to a large town can no longer—as in the past it so often was—be regarded as a purely technical matter but must on the contrary be treated as a hard commercial proposition. This being so it appears to be little less than folly to lavish money on useless adornments such as elaborate buildings and ornate architecture, for it is to be remembered that as a building cannot produce electricity a plain effective housing for the generating plant is all that is really required, Money can be better spent by providing the highest class machinery which is productive rather than on elaborate buildings which are non-productive.

I may say that present day practice in Great Britain leans towards cheap buildings for power stations. The two large power stations at Carville and Dunston of the Newcastle Electric Supply Co., which supply practically the whole of Tyneside and over a large area in the counties of Durham and Northumberland, are covered almost entirely with galvanised corrugated iron sheeting instead of brickwork; they are not sightly but practical. Incidentally the company is one of the most prosperous of the electric supply undertakings in the Kingdom.

The above remarks are made in anticipation of possible criticism of the style of building which it is proposed to adopt. The sad waste of money on the Fearon Road station, as originally built, would not have been incurred had the buildings been properly designed for the purposes which they were intended to serve.

Turbines-Alternators and Condensers.—During the last four years enormous progress has been made in the design and construction of turbines and high-speed alternators. This improvement has been accompanied by a corresponding decrease in the cost of such machines. Whereas four years ago or less the combined price per kilowatt for turbo-alternators and condensers was in the region of £6 to £7 tenders recently received for the Shanghai machines worked out as low as £2.6 per kilowatt. The battle between the re-action and the impulse type of turbine seems to have been fought out resulting in a compromise between the two, as represented by some well-known makers; whilst others, equally well known, have adopted designs which retain the impulse principle throughout. It is yet too early to prophesy which of these two types will ultimately win, but for all practical purposes, as far as I can judge, there is little to choose between them, although one may as an engineer lean a little towards some designs more than others on account of certain mechanical details which appear to have been better thought out. Practically, however, the final selection of a turbine is reduced to efficiency in steam consumption and cheapness.

The great question at present exercising the minds of engineers is the speed of turbo-generators. The tendency of Continental makers is to build turbo-alternators for running at much higher speeds than was practicable a few years ago, and some British makers have already followed this example, doubtless to meet competition. There is not so much difficulty in building a turbine for higher speeds, in fact some turbine designers welcome the new tendency for increased speed. The chief difficulty arises in the construction of the rotor of the alternator which is more difficult to construct sufficiently strong mechanically to withstand the enormous peripheral strains set up at high speeds. An advance has been made by more than one firm by making the rotors solid, thus increasing their mechanical strength; and by an ingenious system of ventilation appreciably diminishing the dangers from overheating which have been the causes of so much trouble in the past.

Another determining factor again is the relationship of the critical speed of the turbine to that of the alternator, and it is in this connexion that much difficulty has been experienced during the evolutionary period through which the various types of machines have been passing. I was very struck by the thoroughness and careful study displayed in the design and manufacture of the majority of the turbines and alternators which I saw. The comparative state of excellence which one now finds is very noticeable when one looks back only a few years to the earlier machines built before the inherent troubles of high-speed alternators were fully appreciated and understood.

The standard speeds for 50 cycle 4 pole and 2 pole alternators are 1,500 and 3,000 revolutions per minute respectively. The higher speed machines possess some considerable advantages the more important of which are:—

(1) Smaller size—therefore less material used in their construction, and less ground space required.

(2) Because of the above they are cheaper in capital cost.

(3) They are more economical in steam consumption therefore a further saving in running costs can be effected.

With regard to the selections for Shanghai. If turbines running at 3,000 r. p.m. were chosen a saving in capital costs of about £3,000 could be made, and were Shanghai situated in Europe, within easy call of the builders, I should unhesitatingly recommend the Council to adopt the higher speed machines at 3,000 revolutions. The tendency for higher speeds has set in and it is, in my opinion, only a question of time when they will become common. Those particular makers who are the more active advocates of higher speed assure me that there is little more risk attaching to the higher than to the lower speed machines, and I am inclined to agree that this may be so. But one may be pardoned for hesitating to accept these higher speeds for a place like Shanghai at the present moment because, although there are some machines of this type and of the same output as the Shanghai machines, viz., 2,000 kilowatts already built and in operation, there are many more of the lower speed ones running with success and reliability. In a few more years the safety or otherwise of the higher speeds will have been amply demonstrated; at the moment, however, I must place reliability before cheapness, and submit that at the present stage of development the capital cost of £15,025 for 1,500 revolutions as against £12,025 for 3,000 revolutions is justified as an additional insurance against, not probable, but possible trouble.

The recommendations contained in Messrs. Preece, Cardew & Snell's report regarding the various contracts are made upon our joint selections. With regard to the final selection of the Turbo-Generators (Contract No. 1) the issue is between the tender of Messrs. Richardson, Westgarth & Co.'s turbines, with Messrs. Siemens Bros. & Co.'s generators, speed 3,000 revolutions per minute, and the Allgemeine Elektricitats Gesellschaft at 1,500 revolutions.

It will be noted that the Allgemeine Elektricitats Gesellschaft require only 21-26 weeks for delivery whilst Richardson, Westgarth & Co. require 40-44 weeks.

	Richardson, Westgarth—Siemens.	Allgemeine Elektricitats Gesellschaft.
Speed—	3,000 R.P.M.	1,500
Steam consumption per K. W. Hour	14.66	14.75
Price	£12,025	£15,025
Delivery	40-44	21-26 weeks.

Should the Committee incline towards the saving of £3,000 I would submit that the safer course would be to adhere to the lower speed machines even at the extra cost. At £15,000 we are obtaining the machines 50 per cent. cheaper than originally estimated owing to the improved and cheapened methods of building. Furthermore, the question of delivery is important and I cannot advise waiting 44 weeks for delivery when a delivery of 26 weeks can be obtained.

For the reasons already explained I therefore beg to recommend acceptance of the Allgemeine Elektricitats Gesellschaft's tender at £15,025.

With regard to the other tenders the recommendations contained in Messrs. Preece, Cardew & Snell's report coincide with my own. It was impossible in the short time at our disposal to obtain tenders for the *whole* of the extensions and make selections therefrom before my return to Shanghai. For instance, until the choice of turbo-alternators has been finally approved the lay out and quantity of steam, exhaust and circulating water pipework cannot be got out; and again many of the minor accessories will be selected later, but a sufficient sum has been allowed in the estimate for their provision.

Turbine House.—The two turbo-alternators each of 2,000 K.W. which will generate 3-phase current at 50 cycles 6,000-6,500 volts pressure, will be complete with condensers and auxiliaries Provision is made for the speed regulation of the turbines to be controlled electrically from the main switchboard operating bench so that one man should be able to control the turbines as well as the alternators, station power and lighting circuits and the trunk feeders. The advantages of this system of control will be more appreciated as the station grows in size and contains more generating units.

Pressure Regulation.—The voltage of the system will be automatically controlled by an electric regulator; fluctuations in pressure due to careless hand regulation will thus be avoided.

Air Pumps.—For the air and discharge pumps of the condensers, those of the rotary type have been selected. This type appears to possess advantages over the usual reciprocating type.

Auxiliary Motors.—All the auxiliary plant in the station, with the exception of one spare steam pump for boiler feed, will be driven by 3-phase induction motors of the squirrel cage pattern.

Travelling Crane.—A 30-ton electrically operated travelling crane is being provided for handling material in the turbine house.

Extra High Tension Main Switchgear.—The main high-tension switchgear has been specially designed for the safe and efficient protection of the generators and feeders which it has to control. It is in conformity with the most approved of recent designs The idea has been to make it both fireproof and foolproof and to so arrange it that only by gross carelessness could accidents happen. The switches are of the remote control electrically operated type built into concrete cubicles and situated under the gallery on the engine room floor level. The switches are liberally designed for operating under severe conditions such as may occur when the station reaches a plant capacity of 16,000 to 20,000 kilowatts.

The arrangement is such that unlimited extensions can from time to time be made without interrupting the working of the station.

The control bench, upon which all the instruments and the small switches for controlling the large main switches are fixed, is to be situated on the first gallery on the east side of the turbine room. No high-tension current is carried to this operating bench all the instruments and operating switches being supplied with low-pressure current through current and potential transformers placed on the floor below in concrete cubicles. Even when the station assumes very large proportions the control bench will occupy but a small space on the gallery, so that one switch attendant should be able to control the whole of the generators and feeders.

Switchgear of cheaper construction could be obtained, but it is unwise to instal anything but the very best since the switchgear is the most vital section of a power house equipment, and in the event of trouble with it the whole of the system is likely to be affected and damage of a serious nature may result in the power house itself. None of the tenders first submitted quite met our requirements, but that of the British Westinghouse Co. at £1,512 was chosen as being the best, and was provisionally accepted subject to certain alterations in the design which were considered advisable. The amended tender of £2,000 cannot be considered excessive for the important modifications called for. It is to be noted that this sum includes the low-tension switchgear for controlling the station power and lighting circuits. This low-tension switchgear is of the "colliery" type and is entirely enclosed in metal cases.

Protective arrangements are provided for the generators by reverse power relays. The feeder and station circuits are protected by overload relays having an inverse time element. The opening and closing of the high-tension main switches is arranged for direct current at 100 volts pressure.

Battery.—A small battery is provided for the switching operations above described. In addition the battery will furnish a supply of current for emergency lamps which are being installed for use in case of failure of the main supply.

Pump House, Intake and Coal Wharf.—The water for condensing purposes will be drawn from a dredged intake 40 feet wide. This intake will be so constructed that the eastern side will be partly formed by the side of the pump house. The western side will consist of a concrete wall or bund upon which a travelling jib coal crane will run. This crane is to lift the coal from barges moored alongside the wall, and dump it into an automatic coal weigher from whence it passes into the conveyor. The intake, as it may be called, is being designed sufficiently large to allow enough water for all probable condensing purposes to be pumped. The pump house itself will be built at the east side of this intake. The pumps, which are of the submerged vertically driven centrifugal type, are to be placed at the bottom of the pump house at a depth of about 20 feet and well below lowest tide level. The motors for driving them are fixed above ground level so that in the event of floods the circulating water supply should not be interrupted as the pumps themselves can work under water. The layout of the pumps and pipework is such that extensions can be conveniently made. I wish to draw attention to the increases in the estimated cost of this intake and pump house in the final estimates above the original. The reason is this, that in my original plans I arranged for the motors and pumps to be above ground and for the suction pipe only to be carried down below low tide level. Investigations in England at some of the more important power stations convinced me that the advantages of placing the pumps below water level are so great that the higher capital costs of constructing a low level pump house are justified. The importance of a well arranged and efficient pumping plant was mentioned in my original report; further inquiry and recent information gathered strengthens my contention and proves that it would be unwise to curtail necessary expenditure on this important section of the work.

Boiler House.—Four Babcock and Wilcox land type boilers will comprise the first instalment. The land type has been selected as the more suitable since considerations of ground space, which rendered necessary the use of the marine water-tube type in the Fearon Road station, have not to be taken into serious account. Each boiler is designed for a working pressure of 180-lb. per square inch, and an evaporation of 22,000-lb. of water per hour. Internal superheaters are fitted for superheating the steam 150° Fah.

Economisers. — Separate Green's economisers for heating the feed water are provided, one for each boiler. They are fitted with the usual sets of tube scrapers which will be electrically driven.

Mechanical Stokers.—A very important feature of the new boilers is the arrangement of the chain grate stokers and the method of applying air to the furnaces. With the existing stokers at Fearon Road station only certain grades of coal can be successfully burned. The new type which has been selected has been specially designed for burning very low grade fuel, and it is hoped that a considerable saving in the annual coal bill may be effected by its adoption. I may mention that this type of grate is equally suitable for high grade coal.

I recently visited one of the South Wales collieries where coal was used which had lain at the pit mouth for some twelve years or more, and which would not burn under any other conditions of firing. The coal is of such poor quality that the proprietors made no attempt to sell it, but now that their boilers are fitted with the new stokers the coal has at once become useful. I believethat by selecting these mechanical stokers a very appreciable economy in the costs of production will result. At the Council's new power station the mechanical stokers will, in common with all the auxiliaries, be driven by electric motors.

Chimneys and Induced Draught.—No costly brick chimneys will be built, but two short steel shafts are provided for. Each shaft will be capable of dealing with a boiler capacity of 5,500 K W. working with induced draught. The fans for producing the draught do not, as in most induced draught systems, have to pass the hot flue gases but are arranged separately in such a way that they have only to draw in and deliver fresh air which is forced up the shaft by means of a nozzle fixed at the base of the shaft. As the fans do not have to work in a high temperature their life should be considerably longer and the cost of upkeep appreciably less than fans operating under less favourable conditions.

Feed Pumps.—Three boiler feed pumps are allowed for either one of which is capable of supplying the four boilers. Eventually the two pumps will deal with the water for eight boilers whilst the third is spare. The two pumps for ordinary use are of the rotary type electrically driven. The other pump is to be steam driven. The rotary type of pump now finds much favour possessing as it does many advantages over the older reciprocating type most commonly used.

Coal Handling Plant.—Provision is made for storing about 900 tons of coal in overhead steel bunkers placed above the boilers, and 1,000 tons in separate bunkers to be erected outside the boiler house. The bunkers will be fed by means of a bucket coal conveyor arranged to receive the coal from an automatic weighing hopper fed by a travelling jib crane which picks the coal out of the barges. The coal will therefore be conveyed from the barge to the boiler furnaces entirely by mechanical means. Provision is made for handling the coal by manual labour should the conveyor plant be out of service for repairs or other reasons.

Ash Disposal.—The boiler foundations are planned to allow the ashes from the furnaces to gravitate down a slope into the basement where they can be shot into small trucks running on rails. This method has been adopted so that the ashes may be wheeled out to the foreshore where it is proposed to dump them for reclamation purposes. The gauge of the truck is one metre. The idea is that by adopting this gauge ashes may at some future time be conveyed over the tramways system for building or road making purposes wherever required ; and material or stores may be transported from the Settlement and carried direct on to the Council's property.

PART II.

General.—The Deputy Electrical Engineer, in the Annual Report for 1910 written during my absence from Shanghai, shews that the estimated maximum load at the Fearon Road generating station did not reach the anticipated maximum. He attributes this, rightly, to the effect of the general use of the metallic filament lamp ; and also to the trade depression as being responsible for a very poor demand for office lighting during the two last months of the year. In former years the maximum load on the station has always risen abnormally during November and December because, in addition to the thousands of new lamps connected to the mains throughout the year, the business district has taken a heavy demand for office lighting. This last winter there has been a lesser demand from the business quarter which has been reflected in the smaller increase in the maximum load on the generating station.

In face of the above it may not unreasonably be asked if the further large extensions are yet justified, and whether they might not be postponed for a year. It is of course impossible to foretell how far the trade of Shanghai is likely to improve this year and therefore equally impossible to say whether the office demand next winter will bear something more of its former influence upon the winter demand. It is, however, possible to draw deductions from the experience of other large electricity supply undertakings in Great Britain and apply them to Shanghai. Almost every undertaking has suffered a temporary check upon the lighting demand directly due to the metal lamp, and those undertakings which have no important power demand have had to be content with diminished revenues. I think we are to be congratulated upon making a profit practically equal to that estimated, and for this reason the future can be looked to with increased confidence. I have made careful investigations in England and find that nearly all those undertakings which have felt the effect of the metal lamp are now emerging from the stages of depression and are going ahead again with renewed prosperity. This is manifest on all sides and perhaps no better barometer of the trend of events is to be found than in the increasing number of different municipalities calling for tenders for generating and distributing plant to meet increasing demands. I have always shared the view, in common with many supply engineers, that the metal lamp is one of the greatest aids towards the ultimate triumph of electricity for lighting. It is not therefore mere optimistic guesswork that leads me to state that the near future will see an enormous increase in electric lighting, but because we have in Shanghai so closely followed the lines of the more successful undertakings elsewhere, and because the number of new connexions to the mains is all the time increasing at a greater rate.

Now it is a fact that the cheapest electricity in Britain is obtainable in those towns where the supply undertakings have been developed on progressive lines, and where the supply is on a very large scale. It is the municipalities where, in spite of necessarily large capital expenditure, many millions of units are annually sold for lighting, heating and industrial purposes that the cheapest price per unit is offered. Perusal of the Electricity Department's records will show that although we have been increasing our capital expenditure and total working expenses yet all the time the costs of production per unit have year by year been steadily lowered, the prices charged to consumers reduced, and the profits increased. We are not yet near finality and I can unhesitatingly assure the Committee that if the new power house and the various extension schemes receive the ratepayers' approval the price for lighting can in a very short time be safely lowered considerably. It may seem incredible that with all the increased capital expenditure it should be possible to still further lower the charges for electricity, but when it is stated that the capital costs of the new station, including buildings, etc., work out at about 23 per cent. less than the Fearon Road station, and that the guaranteed steam consumption of the new turbines is some 39 per cent. lower than that of the Fearon Road plant, it is safe to assume a reduction in the running costs of at least 30 per cent, which should be still further improved upon as the output from the station increases. It is to be borne in mind that the new power house buildings, coal handling plant, pump house and foundations are designed to accommodate an 8,000 kilowatt plant, consequently the proposed 4,000 kilowatt plant has to bear, until still further extensions are undertaken, an undue share of the additional capital outlay for the future. When the power house contains 8,000 K.W. of plant the cost per kilowatt installed will be some 40 per cent. below the cost of the Fearon Road station. Although interest and depreciation will have to be paid on the Fearon Road plant yet it is only a question of a few years when it may become more economical to shut it down entirely as a steam generating station and generate entirely at the new Riverside power station. I do not wish it to be inferred that Fearon Road station is obsolete. On the contrary it is up to date and contains many modern devices not found in the average generating station in Europe. The two new mixed pressure turbo-alternators now being installed are typical of the most up-to-date design. Nevertheless the largest sized units in the station are of 800 kilowatts capacity and the steam consumption of these sets compared with 2,000 K.W. and larger sets is relatively high. The time then comes, in the history of most large systems, when to continue to operate an old station, old in the sense of efficiency not necessarily in years, becomes inadvisable for financial reasons. When that time arrives a concern run on sound business lines will cease to operate plant which yields a smaller return on the money invested than will a larger and more efficient one. Quite recently one of the largest electricity supply corporations in the United States built a new station equipping it with several units of 10,000 kilowatts each. After working this plant for a few years the 10,000 K.W. sets were replaced by 20,000 K.W. units because of their higher efficiencies. It paid the corporation to take this step as by so doing the total operating expenses were reduced. Within the last two years the Underground Electric Railways Co. of London Ld. entirely re-equipped their Chelsea power house with new turbines having much lower steam consumption. I understand that the saving in the coal bill has already more than paid for the capitalised cost of the new turbines. There were, it is true, other reasons which influenced the Underground Co to make the drastic change, but the fact remains that on grounds of economy alone the change has been justified. I could quote many municipal and company electricity undertakings which have followed the course which it is proposed the Council should adopt. I have personally visited towns where old stations are lying idle and the whole supply is being given from new ones. I do not pretend that the time has yet arrived for closing down Fearon Road Station, but I do contend that if the proposed extension scheme is carried out it will be but the prelude to such a policy in the future, a policy which there is every reason to believe will result in a considerable cheapening of electricity in Shanghai coupled with financial success.

Residents may not appreciate the fact that the Council is supplying electricity at rates lower than those in force in the majority of English towns for lighting, heating, cooking, power and traction. With regard to the last named the price charged to the Shanghai Tramways Co., is well below the average. It may also be interesting to note that the price of electricity for lighting is equal to approx. Tl. 0.21 per unit in Colombo, Penang, Singapore and Hongkong as against Tl. 0.13 in Shanghai, a difference of 38 per cent. which if the new scheme is authorized may soon be increased to 50 per cent.

Power Supply.—This report would be incomplete without some reference to power supply. That electricity is rapidly becoming the chief power for industrial purposes one has only to visit the industrial centres in Great Britain and the Continent to believe. In passing through the many electrical manufacturing works recently a noticeable feature was the large number of motors—both large and small—that were being made for various industrial purposes. One large motor which I saw was designed to work up to 13,000 horse power, it was built for a rolling mill. Many people seem to imagine that the electric motor is only suitable for small powers. As a matter of fact electric motors are now built which are much larger than any gas engines so far constructed. Wherever motors are used for driving purposes the users find them in every way preferable to the older steam or gas-driven engines. I was courteously allowed to inspect a large electrically-driven cotton mill in Manchester, which is supplied with power from the Manchester Corporation mains. In Sunderland I was shown over a large flour mill which was formerly steam-driven but now is run by electric power taken from the Corporation mains. At both the Cotton and the Flour Mill the opinion of the owners was distinctly in favour of electricity, and at both places I understand that the output from the milling machinery has been increased by several per cent without additional power cost. At Sunderland the millers intend to equip their other mill for electric drive so satisfied are they with the running of the first mill. Time did not permit me to visit more mills in actual operation but I could instance many where electricity has supplanted either steam or gas to the advantage of the concerned.

I have endeavoured to show that our lighting business has closely followed the lines of large undertakings at Home. In the same way the power business is following. There are at the end of January this year 157 electric motors connected to the mains the aggregate horse power of which is 1,065. Each month more are added, besides which one of the local flour mills has arranged to take power for a 150 horse-power motor for driving the entire mill. Now it is evident that unless there were a demand for this class of work we should not have succeeded in building up the power business to the extent we have. Home undertakings have had to pass through the pioneer stage until the industrial public was educated up to the advantage of electric driving; once that point is reached then the demand increases at a much greater rate because the larger power users begin to awaken to the commercial advantages available.

I have always advocated the policy of catering for the large power user and have on more than one occasion indicated how the development of a large power supply benefits directly the lighting consumer. I had many opportunities in England of discussing the power question with some of the leading engineers in the country, and without exception their advice to me was to develop the power business to the utmost. The present low charges for electric power can be still further lowered profitably, and if the result of lowering them is to secure more power users, as it undoubtedly would, then the costs of production will be lowered all round and the lighting consumer will benefit by a cheaper supply for lighting.

It would be unfortunate if the new extension scheme were not carried into effect. An indefinite postponement would mean throttling the department's activities the direct result of which would be to postpone the time when it would be possible to reduce the present lighting rates, therefore it would seem that the community as a whole would be the loser should the ratepayers' approval be withheld. I am aware that many people disagree with municipal enterprise of this nature and consider that the Electricity Department should merely supply a demand rather than actively set itself out to create one. I respectfully submit that no business man would seriously entertain that application to his own business, therefore it would seem illogical to oppose the department because, after all, it is run as a local business concern for the benefit of the Shanghai community generally. That the Department is in competition with other enterprises cannot be denied, but so long as it is a municipal concern it is surely the duty of those responsible for the direction of its affairs to give the best public service at a reasonable price, in other words to operate it to yield the best return to its owner—the community.

The following are the names of the firms whose tenders are recommended for acceptance :—

		£
Boilers, stokers, chimneys fans, etc.	Messrs. Babcock & Wilcox Ltd., London & Glasgow.	14,000
Turbines, generators and condensers.	The Allgemeine Elektricitats Gesellschaft, Berlin.	15,025
Underground cables, bitumen troughing and boxes.	Messrs. Siemens Bros. Ltd., London & Woolwich.	12,079
Main & Auxiliary Switchgear.	British Westinghouse Co., Ltd., Manchester.	2,000
Station Transformers.	The Allgemeine Elektricitats Gesellschaft, Berlin.	650
Station Battery.	The Chloride Electrical Storage Co., Ltd.	250

Tenders for the steelwork have been received but the final selection has not yet been made.

Tenders for the outside coal bunkers, conveyors, cranes, station cables and wiring material have yet to be received.

T. H. U. ALDRIDGE,
Electrical Engineer.

STATEMENT SHOWING COMPARISON BETWEEN ORIGINAL ESTIMATE FOR RIVERSIDE STATION AND PRESENT ESTIMATE BASED ON TENDERS RECEIVED.

	Original Estimate.	Revised Estimate
	£	£
Turbo-generators, condensers and pipework	30,000	17,000
Switchgear	1,750	2,250
Transformers		650
Battery	500	250
Cables	1,000	1,000
Boilers, economisers, motors, fans, pipework, chimneys, flues, pumps ...	19,090	17,000
Steelwork for building, cranes, steelwork for bunkers, roofing and coal conveyor	8,500	11,500
Storage coal bunkers ...	—	* 2,500
Underground mains ...	13,000	12,000
	£73,840	64,150

* The original estimate did not provide for extra coal storage bunkers, but these are considered very necessary and have consequently been included in the final contracts.

	Tls.	Tls.
Foundations, walls, etc. ...	30,000	30,000
Erection of steelwork and machinery	15,000	20,000
Excavation for mains ...		*10,000
Quarters for foreign and native staff	35,000	35,000
Concrete bunding for condenser intake, pump house and coal wharf ...	7,000	20,000
Contingencies	10,000	10,000
Tls.	97,000	125,000

* Included in original estimate in sterling.

SUMMARY.

ORIGINAL ESTIMATE.

£73,840 @ 2/6 = Tls.	590,720
Local Expenditure	97,000
Tls.	687,720

REVISED ESTIMATE.

£64,150 @ 2/6 = Tls.	513,200
Local Expenditure	125,000
Tls.	638,200

REVISED ESTIMATE @ 2/4½.

£64,150 @ 2/4½ = Tls.	540,000
	125,000
Tls.	665,000

Lower exchange making a difference in the estimate of Tls. 26,800.

T. H. U. ALDRIDGE,
Electrical Engineer,